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ABSTRACT

This paper examines several theoretical and empirical issues, together with new directions in thinking, which have emerged as the result of significant research done on the PLATO IV computer and with the advancement of the language pedogogical theory. CAI previously encountered three basic problems: (1) the cost of hardware, (2) the lack of adequate software, and (3) the algorithmic ability of the machine. The first two difficulties have been overcome by PLATO IV. The attitude conveyed by the Goedel Theorem in the field of mathematics and the algorithmic ability of the machine are no longer the center of controversy in the humanities. The focus is on how to exploit the capabilities of the computer and how to establish a meaningful interaction between man and the machine. Thus, attitudes toward machines have changed significantly. Theoretical problems are investigated along two parameters: computer-based and non-computer-based pedagogy. The former incorporates such questions as the various roles of the computer and which roles a humanist should assign to it. The "concept of sequencing" is discussed. The discussion of empirical issues includes questions such as whether or not the machine dominates man. (Author/CLK)

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0. INTRODUCTION

Recent research and developments in the area of technology and Computer-Assisted Instruction (henceforth, CAI) have answered some fundamental questions (See Section 1.0) and removed serious doubts about the plausibility of CAI. The emergence of PLATO IV can best be characterized as a major break-through in this field. PLATO IV has caused the spectrum of CAI to undergo radical changes by allaying the skepticism about the future of CAI, which was voiced earlier in some quarters. However, it is generally accepted among computer scientists and humanists alike that the current state of CAI can best be characterized as an era of innovation and growth; and of conflicts and controversies.

The aim of this paper is to focus attention on the

significant current developments and issues in the computer-based education. It is also shown that although empirical data gathered from research projects on PLATO and other computers have demonstrated a considerable growth of this field, it still continues to be a problematic area of educational instruction.

This paper is divided into four sections. Section (1) examines the current scene of CAI in the context of the pattern of its growth in general; section (2) deals with the new theoretical problems as the domain of CAI expands; section (3) focuses on the several empirical issues which are prevalent in the computer-aided education. The last section presents the summary and conclusions together with the future implications of CAI. In the course of my discussion, I will be treating questions such as what a humanist has to offer to the various areas as research advances in the fields such as linguistics, psychology, education, etc.

1.0 DYNAMICS OF CAI

In the initial phases of CAI, theoretical and attitudinal variables coupled with economic factors cast doubts about the credibility and the reality of CAI. Such pessimism about programmed education led to several

misconceptions about it. In what follows, I will discuss the problems related to the ability of man and machine which played an important role in portraying the dark picture of CAI.

During the last decade, the skepticism about the future of CAI grew primarily on the following grounds:

(a) the algorithmic abilities of the machine,

(b) the cost of hardware (See Oettinger, 1969), and

(c) a lack of adequate software (See op. cit.).

The first problem (a) stemmed from the attitudes such as those conveyed by the Goedel Theorem in mathematics which argued the superiority of man over machine. Such a line of thought on the part of many educationists, technologists and others led to the development of an unfortunate tendency to underestimate the capabilities of computers.

However, on the current scene of CAI, the algorithmic abilities and the question of inferiority or superiority of the machine is no longer a center of controversy. Instead, the focus today is on such questions as how to sucessfully exploit the capabilities of computers and how to establish a meaningful interaction between man and the machine (See Marchand, 1973). Such developments exhibit a considerable attitudinal shift among humanists, technologists, and scientists towards the machine. The

development of such a balanced and desirable attitude towards computers was the primary factor in the emergence of the current trends in the area of CAI.

1.1 RECOGNITION OF THE PROPER ROLES OF MAN AND MACHINE

With the decline of the 'second class citizen'-attitude towards the machine, the proper roles of computers and man were recognized on the basis of their respective abilities and limitations. It was felt by the humanists and the scientists alike that although the generative power and the creativity of human brains cannot be matched or rivaled by computers, yet, fortunately, the powers of man and machine are quite different in nature. The computer is accurate and strikingly fast. Its memory is vast but it can only retrieve facts by simple addressing methods. Also, the computer can deal with exceedingly complex sequential logical operations in which multiple logic sequences are superimposed upon one another in ways that would defeat the most skilled human (See Martin, 1973:7). Even in such a challenging job, the computer is error-free.

1.2 COMPLEMENTARY ABILITIES: THE BASIS FOR CO-OPERATION BETWEEN MAN AND THE MACHINE

The different and complementary patterns of thinking present in man and machine, i.e. generative and associative thinking of man and the ultrafast sequential logical operations by computers, provided a basis for close co-operation between them. As a result of it, considerable research went on to exploit their optimal potentials; and with the development of PLATO, it was generally accepted that the desired goals of CAI (such as providing individualized instruction) can be actualized in the near future. The teaching strategies developed by PLATO introduced a totally different concept of computer-based education (See Alpert and Bitzer, 1970). Not only did it offer a remedy for various misconceptions about computer-assisted instruction which were prevalent at that time (and are still present to this day), but also rejected the parallelism between the automated version of Skinner's teaching machine and the computer-assisted instruction. Also, PLATO made it possible to empirically attest the capabilities of inanimate teacher, i.e. PLATO itself, by recording detailed data for measurement and testing. Thus, PLATO exhibited that the algorithmic power of machine has been overly underestimated in the earlier literature.

The second objection with regard to the cost of hardware which was earlier advanced against CAI was also falsified by PLATO. On the economic front, it also made CAI plausible by radically reducing the cost of the per student hour to 35 cents. In other words, the CAI was not the white elephant which it was feared it would be nor was it a laboratory curiosity. Lastly, the question of lack of adequate software system was also satisfactorily answered by PLATO. It is true, as reflected in the figures given by Holland and Hawkins (1972:335), that the advances in adequate software in the humanities are poor in terms of quality and quantity. However, the underlying factors for such a poor state of affairs were (a) the dependency of a humanist on the systems programmer and (b) the lack of closer cooperation between a humanist and the computer-scientist. These were the reasons for the humanist's complaints that computer scientists working in the area of natural languages have not started asking the questions which are fundamental to a linguist. Thus, suggestions such as the following were offered by the humanist, 'In order to share a linguistic burden of language analysis, computer programs must rise above the level of 'Toy Problems' computer scientists have been engaged in so far' (Sinha, 1974:3.5). On the other hand,

Oettinger attacked the humanists for their failure to produce sophisticated programs. He says 'In the 'softer' emerging sciences such as psychology and linguistics the excitement and speculation about the future promise of the computer both as an instrument and as actor tend to be even stronger than in the physical sciences, although solid accomplishments still are far fewer' (Oettinger, 1969:25). Such conflicting statements called for a greater and closer cooperation between computer scientists and humanists; and to devise a simple computer language which could ensure least dependency for the humanist on the computer scientist. PLATO IV also met these demands by devising a very simple language which provided the teachers and the authors in the area of humanities with an opportunity to edit and author any material after a few hours of familiarization with the TUTOR language. Such a development, with the least dependency of a humanist on the programmers, opened the field of CAI to individual teachers and authors involved in classroom teaching. Thus, the spectrum of CAI expanded considerably by involving more and more humanists in this area and, on the other hand, in the area of humanities, there was an increase of sophisticated programs which embodied the insights of various theories of learning together with the challenging classroom problems rather than the arbitrary 'toy

problems'. Below, I will present a few examples to substantiate my claim.

Since the beginning of the seventies, PLATO IV has developed several non-Roman scripts which include the Cyrillic alphabet and non-western scripts such as Devanāgarī, Chinese, Arabic, etc. Several sophisticated and well-tested programs have been developed in the area of linguistics and foreign language teaching, namely, French (Marty, Fernand and Keith Myers), Latin (Richard Scanlon), etc. In order to strengthen my point, I will attempt to present some theoretical and/or methodological procedures which have been built into these programs.

The program in Reading German by J. Marchand exemplifies how a humanist can successfully employ the insights of the theories of learning and processing. The theoretical preliminaries which have gone into the planning of Reading German has been presented in James Marchand (1973:7) 'The philosophy behind this course is fairly simple. Due to the redundancy of human speech, it is not necessary for a person who wants merely to <u>read</u> German to know each and every word, whereas anyone who wishes to <u>translate</u> German finds it necessary to know each and every word'. This is precisely the area in which a humanist has to offer a great deal in order to speed up the process of learning in Computer Based Pedagogy and to bridge the gap between the hardware on the one hand and the software and the CAI on the other.

The Latin Program offers four Computer-Based Courses on PLATO, namely, Beginning Latin, Latin Composition, Vergil's Aeneid (Books 1, 2, 4, 6) and Vocabulary Building through Latin and Greek Roots. These courses focus on various aspects of the Latin grammar such as Lexis, Morphology, Syntax (and grammar). Testing procedures which are built into every lesson comprise branching to remedial problems and diagnostic pre- and post-tests. Variables are used so that each student's progress is charted separately and so that instruction may be individualized. The Latin Composition Course is designed as a complete review of Latin grammar and syntax through the medium of prose composition. Students translate sentences from English into Latin and, when, mistakes are encountered they are given specific information about the error rather than just a general indication of wrong answers. The course contains more than a hundred lessons. More than 1000 students have gone through this course.

The French course by Marty and Myers is even more ambitious since it aims at placing on the PLATO system the equivalent of three college semesters in beginning and intermediate French. After preliminary tests in 1972-1973, the work was begun in the fall of 1973. At this point, the course is under operation and more than a hundred students have gone through this course. It is the

estimate of the authors that a total 6000 hours of work will be required before all the required computer programming is completed in 1978. At that time, each lesson will provide each student with a thorough error analysis. A careful theoretical as well as methodological planning, on the basis of an analysis of the advantages and drawbacks of the computerized version versus the programmed text when used for out of class, has gone into the body of this course. This analysis is based on the data obtained from grades, amount of time spent by students on the computer systems, observation of students' attitudes and informal discussions. The course is individualized to the extent that it presents exercises according to the needs of each student; total individualization would have required that the computer itself create individual sentences and items. However, authors point out that with our present computer-oriented theories of syntax, this does not seem possible. (See for detail Marty and Myers 1975).

Two Computer-Based Courses which are offered by Professor Cheng in the area of Linguistics are: Computational Linguistics and Introduction to General Phonetics. These courses were first offered in the Fall, 1973 and Spring, 1973, respectively and more than a hundred students have studied and critically evaluated these courses. Insights gained from the discussion of students' difficulties

and their evaluation were incorporated in the programs in order to get maximal sophistication during the various stages of the development of these courses. The feature of animated graphics has been fully exploited to increase the effectiveness in the teaching of the articulatory and acoustic phonetics, which cannot be otherwise achieved in the real class-room situation. The program has been utilized for the last six semesters at the time of writing this paper and is equipped with the potential of recording the individual student's performance.

On the other front, research is being conducted to develop new tools and machines to interphase with PLATO. Such developments will have serious implications in research and teaching. As, for example, machines are being constructed to interphase with PLATO for phonetic studies by Cheng. The work is under way on a pitch program that extracts fundamental frequency of a voice and displays it on the PLATO's screen. These developments will facilitate the study tone and intonation in a more sophisticated way. Beside this function, it will be possible to simultaneously carry on calculations and comparisons of different variables involving pitch and tone. At present, such functions are not possible using the existing technical devices.

In the area of Semantics and the understanding of natural languages, the computer scientists have attempted

to deal with challenging problems. The current linguistic models are being employed to set forth the ways of representing information and meaning within a language comprehending system (See Winograd, 1972; Simon and Siklossy, 1972). A few encouraging attempts such as those by Winograd, Simon and Siklossy, have been made by computer scientists to construct natural language learning programs despite the current thinking in linguistics and psycho-linguistics that language learning by a human child is an extremely complex and arduous task assisted by the innate capacity and the sophistication of his brain. At this point, the parallelism between the current mechanistic conception of language learning and the earlier skepticism about CAI can be easily observed. Despite the discouraging factors, many rapid advances are being made in this area. James Martin (1973) has devised a design of Man-Computer dialogues. Such developments will likely facilitate natural language learning by computers in the near future. Also, attempts are being made to build the so-called 'thinking power' in the software system which will likely falsify the myth that computers cannot think. Consider, for example, the following statement by Winograd (1972:2) 'We feel that the best way to experiment with complex models of language is to write a computer program which can actually understand language within some domain.

For our experiment, we pretend we are talking to a simple robot, with a hand and an eye and the ability to manipulate toy blocks on the table. The robot responds by carrying out commands . . . , typing out answers to questions, and accepting information to use in reasoning later on.'

In short, during the last decade, the skepticism about CAI which stemmed from the attitudinal, economic and software factors has successfully been answered and the various myths about it have also been successfully demolished with the introduction of PLATO IV. The proper line of thought has been actualized in a very short period which aims at exploiting the complementary talents of man and machine. Employing insights from linguistics and psycholinguistics, the attempts are being made to develop 'thinking' power in machines which hope to further revolutionize the field of CAI. However, in spite of such remarkable and encouraging developments, it will be justified to say that at present CAI is subject to various limitations such as pointed out by Marty and Myers (1975). Hence, the optimal goals of CAI have yet to be realized.

2.0 SOME THEORETICAL PROBLEMS

Since the capabilities of the computer in CAI as an inanimate teacher are subject to several pedagogical and hardware constraints, the first theoretical problem an author, researcher, or a teacher confronts is making an important strategy decision in terms of two types of pedagogies discussed below.

2.1 COMPUTER-BASED PEDAGOGY (CBP) vs. NON-COMPUTER-BASED PEDAGOGY (NCBP)

These two types of pedagogies call for examining several theoretical problems in order to arrive at the crucial decision of selecting CBP vs. NCBP. The evaluationary procedures which determine the choice between them are outside the scope of this paper. In this section, I will dwell on the problems which a humanist confronts when he exclusively chooses CBP. Using the degree of dependence of man on the computer, the CBP may be divided into the following points on the cline of Instruction.

a) Computer-instruction

b) Computer-aided instruction

c) Computer-supplemented instruction (e.g. drills and pattern practice)

d) frivolous projects.

Now the question is, what role the humanist should assign to the computer? Theoretically speaking, CBP should be directed to (a) and (b); and away from (c) and (d) (See Marchand, 1973:2). However, the author must make his own decision from the empirical viewpoint. The strict practice of the theory which results in an uneconomical use of computer or which obstructs learning should be abandoned in favor of NCBP or lower the roles of the computer in the above hierarchy. To make the point more clear, I will cite an example from our computer-based-Hindi-course. This course was directed to 'computer instruction' at least so far as the introduction of the script was concerned. In the real classroom setting, the problem of 'individual pace' governed the choice of such a course. Since the attempt was directed exclusively towards the 'computer instructional' course, several methodological problems were encountered while programming the Devanāgarī script on PLATO IV, however I will not go into details here. (See Bhatia, 1974) In the earlier stages of our research, we attempted to display the formation of the strokes for each Devanāgarī grapheme on PLATO IV. Three different procedures were adopted to achieve this goal. However, several factors such as computer-memory space, software inadequacies, inadequate displays,

etc., led us to abandon such an attempt. Given such a state of affairs, the most economical, practical and feasible solution was to supplement the Devanāgarī script lessons with a handout to demonstrate the process of formation of the strokes.

2.2 THE CONCEPT OF 'SEQUENCING'

With the growth of the domain of CAI, it can be predicted that specific area-oriented issues will emerge in this area; it is not possible to abstract all those issues right now. However, it is a reasonable guess that the issue of 'sequencing' will be the shared feature in various branches of humanities and sciences. Thus, this concept a..its to be extended and modified in the perspective of CBP. In what follows, I will attempt to demonstrate that the concept of sequencing which channelizes the insights of language pedagogy, applied linguistics and psychology, etc. favors the more promising potential of CBP as opposed to NCBP in several areas. Also, sequencing which includes selection, grading, presentation, and testing calls for taking a new look at the CAI.

Psychologists such as Skinner (1958) pointing out the role of sequencing in learning emphasized that 'Programs should be carefully examined by specialists

in human abilities to be more certain that the sequencing of steps is actually psychologically appropriate and maximally beneficial'. Furguson (1954) also pointed out that sequencing (primarily selection and grading) is crucial for the process of learning. He explains 'an individual will learn more readily activities which are facilitated by prior acquisition, and will learn less those activities which are not facilitated or perhaps inhibited by prior learning.' In short, this concept must govern the skill of writing computer-oriented texts and several 'branching' procedures. Also, CAI which aims at providing complete freedom to study material must not overlook this concept. I may add that I am not advocating strict author control over the material in the student mode or 'strict linear sequencing' in the Skinnerian sense. However, the author must not overlook that the sequencing serves a crucial variable in realizing the optimal goals of CAI. Before an author gets ready to violate this concept, he must carefully examine where, when, and how to violate and to make sure that it does not interfere with the process of learning (in favor of unsequenced presentation see Manwell (1972:14; Allen, 1972a)).

Although in CAI, the material presented to the

students is made very interesting by exploiting various modes of presentation and the principles of graphics and visual arts, the crucial consideration which must go in the presentation is the consideration of the 'consumer'. The insight from research in psychology ensures the success of linear, small step presentation techniques in the case of weaker students since such techniques demand less prolonged attention and prove more fruitful than the lengthy ones.

Testing techniques have also undergone considerable changes in CAI (for detail see Allen, 1972). PLATO IV has added new dimensions to these techniques. For example, our computer-based Hindi teaching course includes achievements as well as diagnostic tests. Also an attempt has been made to make some of the crucial exercises 'generative' in nature. In other words, some exercises randomly select questions out of a set of a given questions and present these to a student whenever he signs his name. That is, every time a student signs his name he comes across a new quiz.

3.0 EMPIRICAL ISSUES

In this section, I will discuss such questions as whether or not machines should dominate man. Theoretically,

the answer seems to be very simple, straight-forward and obvious. However, the limitations imposed by machines should not be treated as an obstacle to progress. As a matter of fact, a pattern of logical thinking emerges as the result of such impositions by machines. Consequently, such constraints not only lead to some unexpected and unintended results but also they can affect the direction of teaching methodology. For example, the limitations imposed by PLATO software system set the author thinking on two related areas, namely, one technical and the other pedagogical. These were one, the presentation of a new proposal for the Hindi keyboard, and second, a new methodology to teach the Devanāgarī script, (henceforth, D which enhanced the psychological process of learning. Let me elaborate this point below:

The teaching of the D·S constitutes a prerequisite for the development of the Computer-Based-Hindi Teaching Course. The D·S (used to represent Sanskrit and five other Indic languages) is one of the most scientific and phonetic script among the writing systems of the world. It differs from the Roman Script, in the number of characters and also in the complexity of characters (i.e., unlike Roman the D·S is a non-linear script and employs a large number of diacritics). Since the D·S is a syllabic script, every consonant has two shapes, syllabic and

non-syllabic shape. The syllabic shape of a consonant has a phonetic value of that consonant plus an inherrent vowel [ə] whereas the non-syllabic shape lacks the vowel [ə] as do the Roman consonant graphemes.

The strict limitations of charset space called for many crucial decisions in the course of programming often forcing us to decide between the traditional pedagogical practice and alternative methods that would accomodate the characters within the limited space of PLATO keyboard. Given the traditional sequencing of syllabic characters and non-syllabic characters it would have been practicaliy impossible to program the D·S on PLATO. Such a limitation imposed by machine led us to perform the structural analysis of the D·S consonants which reveal the following generalizations:

First, the non-syllabic shape of those consonants which do not end in the vertical stroke ⊤ (which I will call the C_1- type Consonants) is quite irregular. E.g. the non-syllabic shape of र[rə] is ◌्र[r] .

Second, the non-syllabic shape of those consonants which end in the final vertical stroke ⊤(which I will call C_2- type Consonants) such as ख [khə] = ◌े + ⊤ [kh+ə] is regular.

The traditional writing system as well as the pedagogical practice have treated the syllabic forms as basic without

providing motivation for this position. Also, the irregularity of non-syllabic shape of C_1 type consonants (i.e., the first generalization) seemed to be so widespread that no attempt was made to look for any other structural patterns involving even in respect of the non-syllabic shape of the C_2- type consonants i.e., the second generalization. In other words, the irregular pattern of non-syllabic consonants was accepted as a general characteristic of the non-syllabic consonants. This view was so deep rooted that it even determined the strategies employed in the planning of D·S typewriter. (For details see Bhatia 1974) We exploited the second generalization and proposed to derive the syllabic shape of the C_2 type consonants from its underlying non-syllabic shape with an addition of one stroke ⊤ i.e., the syllabic shape of ख [kha] will be derived from the non-syllabic shape ख् [kh] plus the stroke ⊤ . This proposal had following implications:

(1) The desired goal of programming the D·S on PLATO was achieved, without, at the same time, sacrificing the traditional practice.

(2) Even after programming the D·S, we were left with some char set space on PLATO which means this device proved to be most economical and efficient.

(3) Presentation of a new and efficient proposal for the D·S typewriter keyboard. (See for details Bhatia 1974)

(4) Application of a new methodology to teach the D·S which demonstrated that all non-syllabic shapes are not necessarily idiosyncratic. The derivational nature of syllabic shape of C_2 type consonants enhanced the process of learning the D·S i.e., once the learner memorizes the non-syllabic shape, he can always derive the syllabic. Students were no longer required to remember two shapes separately as compared to the traditional pedagogical practices. In this way, teaching methodology is psychologically more real than the traditional one.

Furthermore, while working on PLATO IV on the Devanāgarī script we were led to notice the shortcomings in the software system of PLATO IV. For example, PLATO IV can store the shapes of characters plotted in the charset. These characters can neither be transformed into a desired size writing (double or 2.5 times bigger than the original plotted shapes) nor can the process of their generation be demonstrated. Although the former shortcoming is not very significant, the latter is very crucial to show the formation of strokes

of a grapheme in foreign language teaching. However, if the system provides the option of displaying the process of generating a character, it will solve the problem of demonstrating strokes of a grapheme in the teaching of a foreign language.

By the same token, it can be claimed that the limitations imposed by computers in the process of communicating with human beings will eventually result in solving the central problem of artificial intelligence, i.e. towards the understanding of human language.

Thus, the domination of machine over man is not an obstacle. It is an aid to critical thinking and better understanding of the theories and a promising step towards progress which ultimately can end the machine's domination over man. Furthermore, there are other empirical issues such as standardization and transportation (See Allen, 1972) which are still crippling CAI. However, PLATO IV is expected to play a crucial role in solving these problems. The serious moves of installing PLATO in Russia and other European countries, as well as some countries in Asia, set us for a bright promising area of CAI. However, efforts must be made to attack problems such as the lack of centralization, publicity, and the utilization of individual efforts in CAI.

4.0 CONCLUSION

In the last decade the area of CAI has undergone radical changes. The development of PLATO IV revolutionized the whole concept of computer-based education. Several sophisticated programs have emerged as the result of the crucial role played by humanists in CAI. With the extension of CAI's domain several theoretical dimensions and area-oriented issues have emerged in this area. Thus even after the solid sweep of achievements this area is problematic as is the general area of education, in several respects.

Since CAI exploits the optimal potential of man, machine and different areas of education, its growth into a model teaching strategy is inevitable. Although Computer-Based education is no longer a laboratory curiosity, a personal note may reflect the attitudinal problems which it faces right now. When some of my students (at the University of Illinois) were asked to work on Computer-Based Hindi lessons, a student responded, 'How terrible! It seems the computer has not spared even the exotic languages!' CAI still faces the attitudinal problems as was the case with the invention of printing in the fifteenth century.

NOTE

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